

# Addressing CGSS Liability

## Using a Risk Log to Better Define "Liability" and Consider Mitigation Options

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# Sample of Risk Log

1. Siting	2. Construction	3. Operation	4. Closure	5. Post Closure	6. LT Maintenance & Stewardship
12-36 months	12-36 months	1-30 years +	12-36 months	Time limit or Performance driven	Indefinite post closure
1.1 Worker safety 1.2 Damage to private property 1.3 Incomplete site characterization 1.4 Public Opposition 1.5 Failure to obtain access or storage rights 1.6 Failure to obtain permit 1.7 Drilling "dry hole's"	2.1 Worker safety 2.2 Damage to private property 2.3 Damage to confinement zone (by fracturing a cap for example) 2.4 Contractor delays / cost over-runs 2.5 Poor well construction 2.6 Failure to adequately complete old wells/boreholes	3.1 Worker safety – OSHA 3.2 Worker safety – CO <sub>2</sub> exposure 3.3 Groundwater: mechanical failure 3.4 Groundwater: confinement zone failure 3.5 Property damage (mineral rights) 3.6 Ecosystem degradation (terrestrial or aquatic)	4.1 Worker safety 4.2 Improper well abandonment 4.3 Failure to adequately install MMV system 4.4 Materials failure	5.1 Groundwater: CO <sub>2</sub> and geochemical reaction products 5.2 Groundwater: brine or gas displacement 5.3 Subsurface property damage (mineral rights) 5.4 Ecosystem degradation (terrestrial or aquatic)	6.1 LT groundwater contamination 6.2 LT Subsurface property damage (mineral rights) 6.3 LT ecosystem degradation (terrestrial or aquatic) 6.4 LT public exposure to CO <sub>2</sub> 6.5 LT atmospheric release (loss of credits / compliance) 6.6 LT lawsuits 6.7 LT third party damage to confinement zone 6.8 Seismicity 6.9 Change in law

## Carbon Sequestration Risks According to EPA's 7/15/08 Proposed Rulemaking

### *What are the risks?*

If Geological Sequestration projects are not managed properly there are general risks to:

- (Underground Source of Drinking Water) USDW's
- Air
- Human health
- Ecosystems
- Geomechanical/Geophysical

### **RISKS TO USDW's (Underground Source of Drinking Water)**

The largest risk of geological sequestration (GS) is its affect on USDW's

It can affect USDW's in the following four ways:

- **Carbonic Acid** -Formed when CO<sub>2</sub> comes into contact with water- acidifies it, and acid causes naturally occurring metals (e.g. arsenic) to move into, and contaminate the water
- **Co-contaminants**: Hydrogen sulfide and nitrous oxides present in the CO<sub>2</sub> stream will endanger a USDW if high volumes of CO<sub>2</sub> are injected
- **Salinization**: Fluids injected in large quantities can potentially force salty water into USDW's
- **Movement out of the storage reservoir**: Injected CO<sub>2</sub> at high pressure can induce or open existing fractures which can increase movement through caprock, out of the storage reservoir, and into USDW's

### **OTHER RISKS**

#### **HUMAN HEALTH**

Released CO<sub>2</sub> at high concentrations can cause :

- Asphyxiation
- Increased breathing rate
- Vision and hearing impairment

#### **ECOSYSTEM**

##### **1) Terrestrial**

- Exposure to CO<sub>2</sub> can cause chronic and acute health effects in terrestrial mammals and birds
- Soil Acidity: changes resulting from increased CO<sub>2</sub> concentrations may adversely impact both plant and soil dwelling organisms

##### **2) Aquatic**

- Impedes fish respiration
- Causes decrease in PH to lethal levels
- Reduce calcification in shelled organisms
- Adversely affects photosynthesis of some aquatic organisms

#### **GEOMECHANICAL/GEOPHYSICAL SEISMIC EVENTS**

- **Reactivate dormant faults**- improperly operated injection of CO<sub>2</sub> could raise pressure in the formation causing earthquakes

***Why we need a new program-what's different about CO<sub>2</sub>?***

UIC regulations currently define 5 classes of injection wells based on similarities in the fluids injected, construction, injection depth, design, and operating techniques. A **new class of injection wells is necessary because:**

***Wells designated for geologic carbon sequestration differ from other wells in the following ways:***

- CO<sub>2</sub> is buoyant and viscous
- Large volumes will be injected at high pressure
- Can endanger USDW's
- Additional construction requirements are necessary: GS well must maintain integrity and stability in CO<sub>2</sub> rich environment for the life of the GS project

***Are there currently any GS sites and where are they located?***

**Sleipner Project-**

- Located off Norwegian coast in the North Sea
- First commercial scale GS project into a saline formation
- 1 Million tonnes (Mt)<sup>\*</sup> CO<sub>2</sub> removed annually from the natural gas produced in nearby gas field
- Injected approx. 800 m below the seabed
- Project began in August of 1996
- Operators expect to store 20 Mt CO<sub>2</sub> over expected 25 yr. life of the project

**In Salah Gas Project**

- Central Saharan region of Algeria
- World's first large-scale CO<sub>2</sub> storage project in a gas reservoir
- CO<sub>2</sub> from natural gas field re-injected into three horizontal injection wells 5,906 ft. deep
- 1.2 Mt have been injected annually since April 2004
- 17 Mt will be stored over the life of the project

**Weyburn EOR Project**

- Beulah, ND
- CO<sub>2</sub> produced at coal gasification plant is piped to Weyburn in SE Saskatchewan for EOR
- 1.5 Mt injected annually
- Combination of vertical and horizontal wells
- 20 Mt CO<sub>2</sub> will be stored in the field over 20-25 yr. life of the project

**Other projects:**

Gorgon Gas Development- Barrow Island Western Australia: The Otway Project-Australia (saline formation), South Qinshu Basin -China (CBM sequestration project) CO<sub>2</sub>SINK project-Ketzin Germany (sandstone saline formation)

\* 1 Million tonnes= 1.2 tons

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**United States Patent Application****20060216811****Kind Code****A1****Cunningham; Alfred B. ; et al.****September 28, 2006****Use of bacteria to prevent gas leakage**

### Abstract

The present invention relates to the use of microbial biofilms and microbial induction of calcium carbonate precipitation to sequester gases in underground geological formations. In one embodiment, methods of the invention can be used to prevent the leakage of supercritical CO<sub>2</sub> in underground geological formations such as aquifers.

Inventors: **Cunningham; Alfred B.; (Bozeman, MT) ; Spangler; Lee H.; (Bozeman, MT) ; Gerlach; Robin; (Bozeman, MT) ; Phillips; Adrienne J.; (Bozeman, MT)**

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